Edge Current Growth and Saturation During the Type 1 ELM Cycle*

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Initial studies have been made with the DIII-D LIBEAM system to examine the behavior of the edge current density j(r) during the Type 1 edge localized mode (ELM) cycle. j(r) is an important component of the pedestal in tokamaks and plays a major role in setting the MHD stability limits for this region, interacting with the pressure gradient ∇p through bootstrap and Pfirsch-Schluter effects. The most deleterious of these instabilities, the Type 1 ELM, can release a substantial fraction of the pedestal energy to open field lines and represents a serious challenge to the plasma-facing components of ITER and other burning plasma devices. The stability threshold for these modes is well explained by the (linear) theory of finite-n coupled peeling-ballooning MHD modes. However, achieving a predictive understanding of the particle and energy losses requires progress on modeling the nonlinear evolution of the instability. Thus, the question of what happens to the edge current during and after an ELM is critical to determining ELM dynamics and ultimate pedestal performance. Important issues are whether or not the edge j(r) remains constant through an ELM, whether current is expelled from the plasma during an ELM and whether a close correlation is maintained between the edge ∇p and j(r). While the ion and electron pressure profiles have been extensively studied, the behavior of the edge current is less known and is typically modeled using various formulations for the bootstrap current. To address these issues, the LIBEAM system provides a finely spaced profile of the edge poloidal magnetic field from which one can infer the behavior of j(r). Previous work has shown a close correlation between the edge ∇p and the growth of large, localized currents for long ELM-free periods; however the j(r) measurement has significant S/N and time resolution limitations. Conditional averaging of the signals for multiple ELMs improves the sensitivity and allows us to examine the dynamics of edge (j, ∇p) growth and decay as a fraction of ELM spacing, or fixed absolute time after an ELM. Initial analysis shows that the current peak can relax by about a factor of 2 within 10 ms after an ELM, consistent with resistive decay times in the edge. The physics mechanism for the reduction of current has not yet been studied.

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*Work supported by the U.S. Department of Energy under DE-FC02-04ER54698.